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Sustainable Forests and Bioenergy Carbon Capture and Sequestration (BECCS) are an Integral Part of Strategies for Decarbonization

April 28, 2025 [Updates on Figure 3, Figure 4, and Figure 5 on May 2, 2025]

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The Problem

Deniers of climate change as a consequence of rapidly increasing CO_2 concentrations in the atmosphere have their heads in the sand. The atmospheric "greenhouse" effect is not an imaginary conspiracy theory concocted to benefit the development of low carbon solutions for the replacement of oil, coal, and natural gas. The greenhouse effect is a fact based on physics and chemistry.

It is getting hotter. Radiative forcing[1] is increasing primarily due to increasing atmospheric carbon dioxide concentrations resulting from the use of oil, coal, and natural gas.

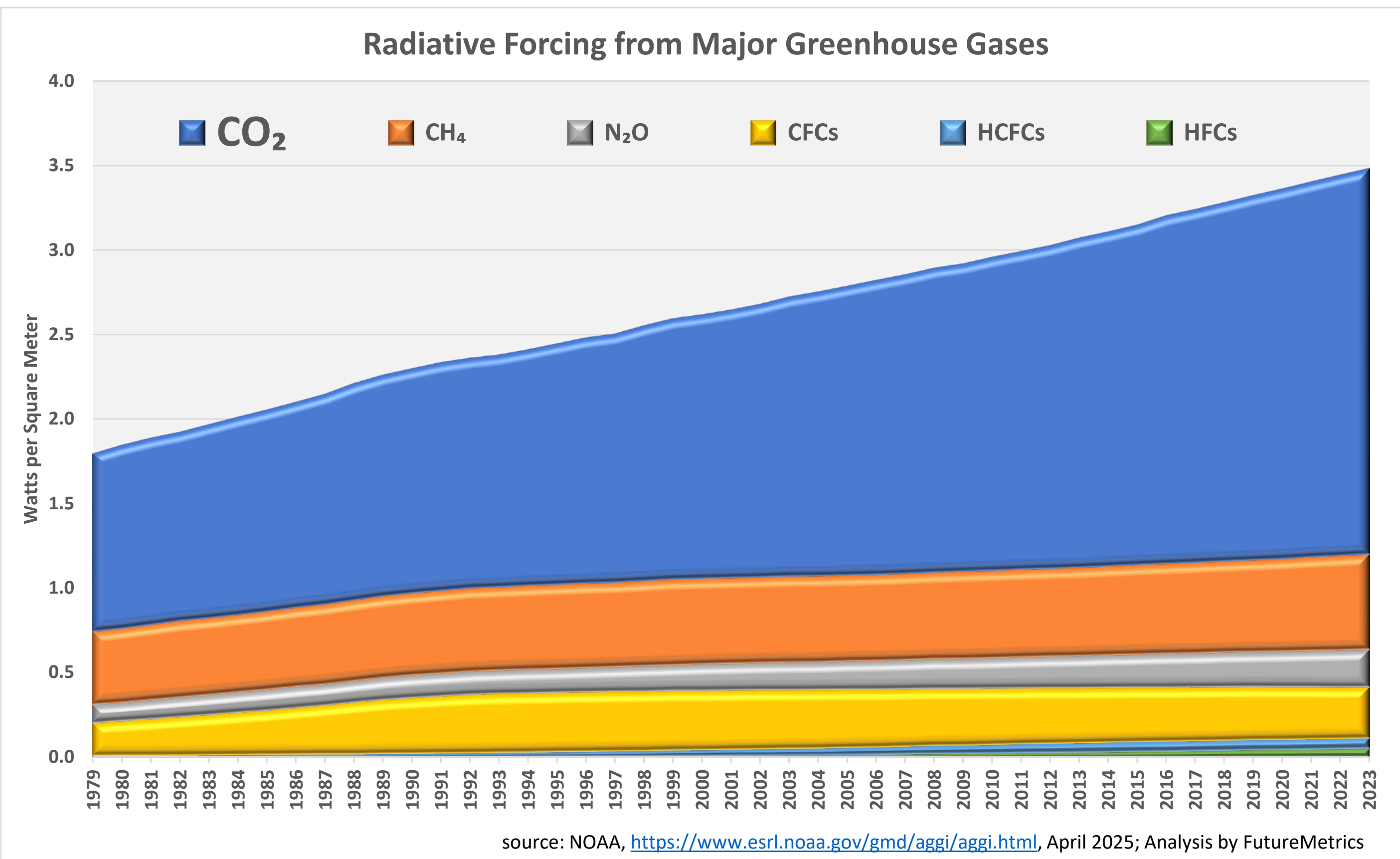

Figure 1 - Forcing Greenhouse Gasses

[1] Radiative forcing is what happens when the amount of energy that enters the earth's atmosphere is different from the amount of energy that leaves it. It is additional heat added onto the planet. See HERE for more.

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The concentrated energy contained in fossil fuels has been the foundation of the social and economic systems that have made living on earth what it is today. But using that concentrated carbon-based energy that was sequestered over millions of years in a span of a few centuries has a cost.

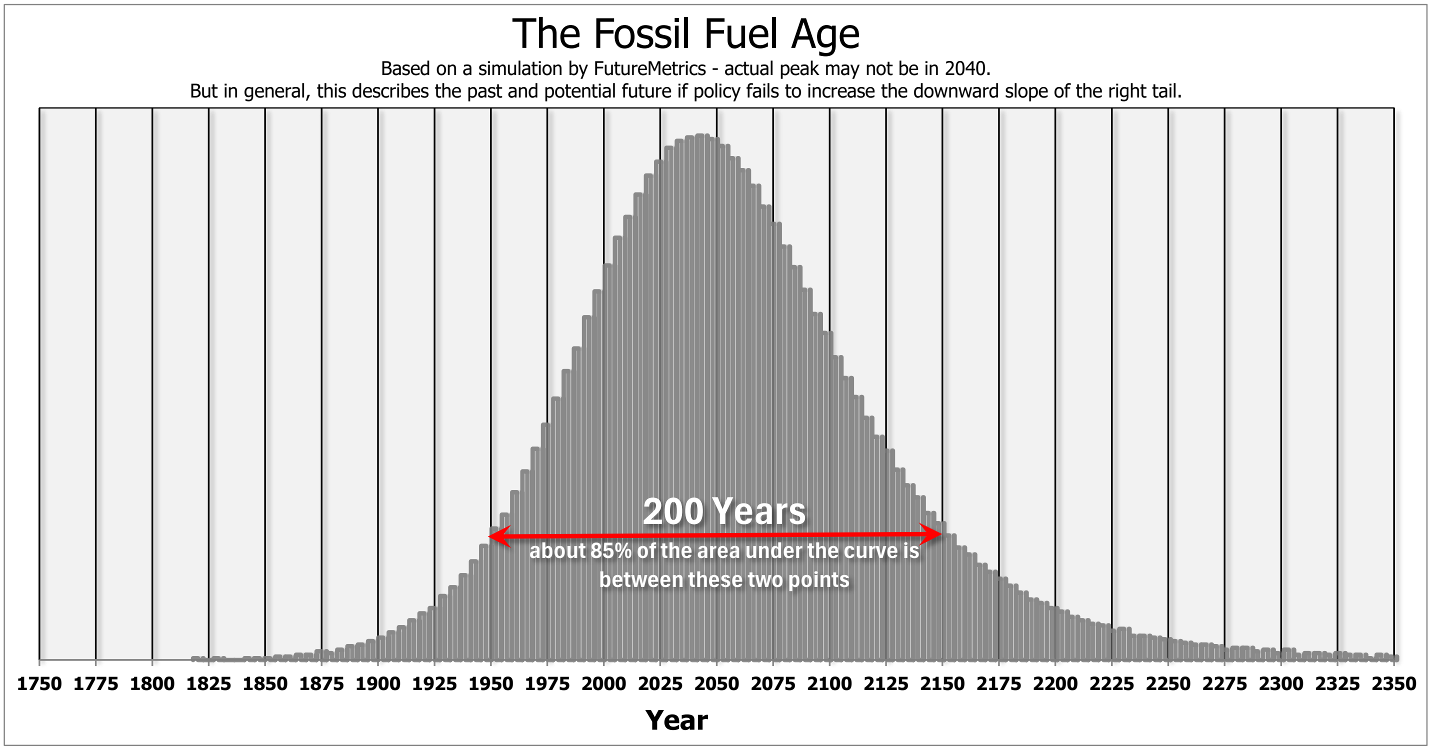

Figure 2 - Fossil Fuel Age Simulation

Although the simulated use of fossil fuels in Figure 2 may not track precisely with the actual use, the general conclusion that most (85% in the chart) of the carbon stored over millions of years in oil, coal, and natural gas (methane) is being released in a span of a few centuries puts a bright focus on the need for a decarbonization strategy.

Notwithstanding the environmental impacts, we are not that many generations away from a world depleted of fossil fuels; and the pathway to that scarcity will create social and economic chaos.

But the environmental impacts are now.

[Updated on May 2, 2025] Just this past week, on April 27, 2025, the earth's atmosphere hit a new record high concentration of carbon dioxide[2].

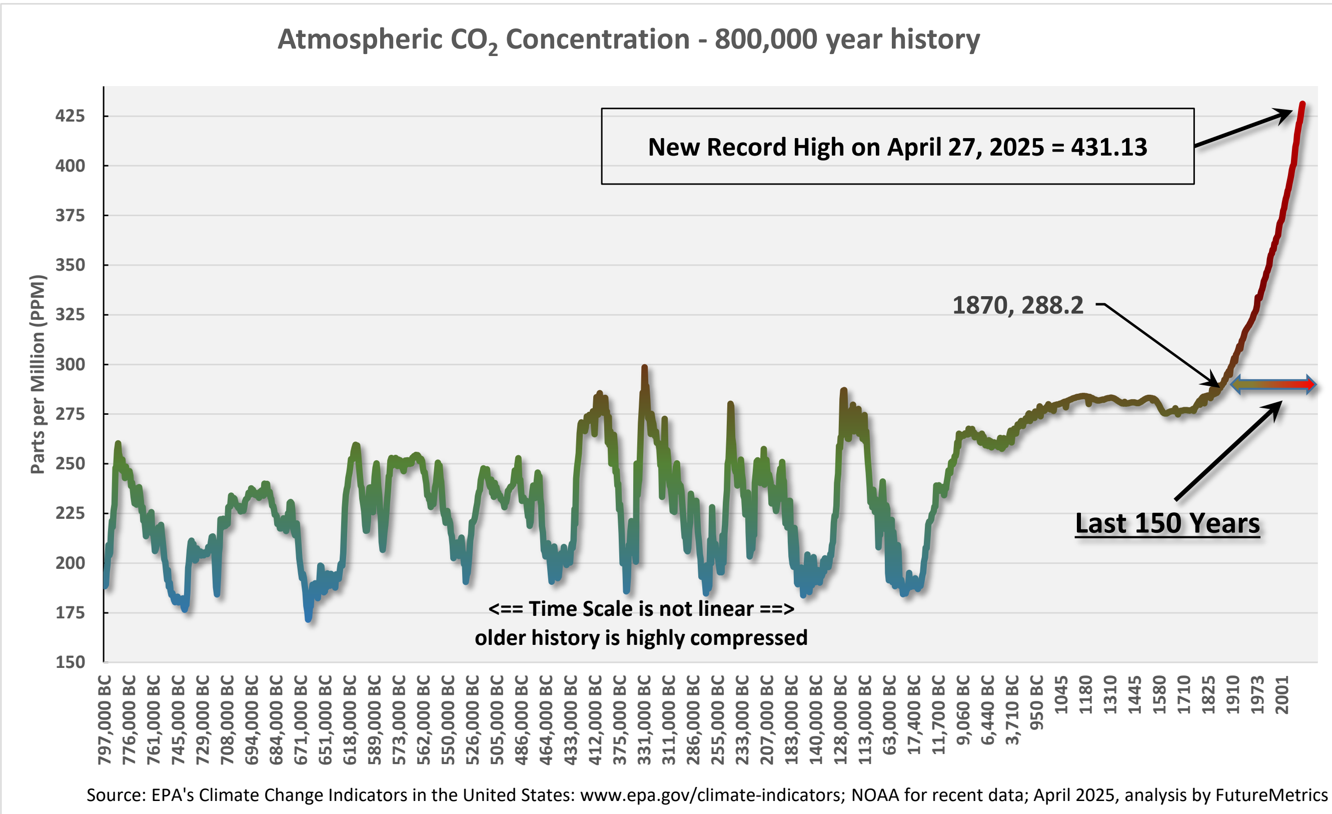

Figure 3 - Atmospheric CO_2 Concentration

And the earth's systems are responding to the very rapid change. Figure 4 and Figure 5 on the next pages document how both the air and the oceans are heating up.

[2] Go to the FutureMetrics homepage and view the interactive "Global CO_2 Levels" chart for details and real time current levels.

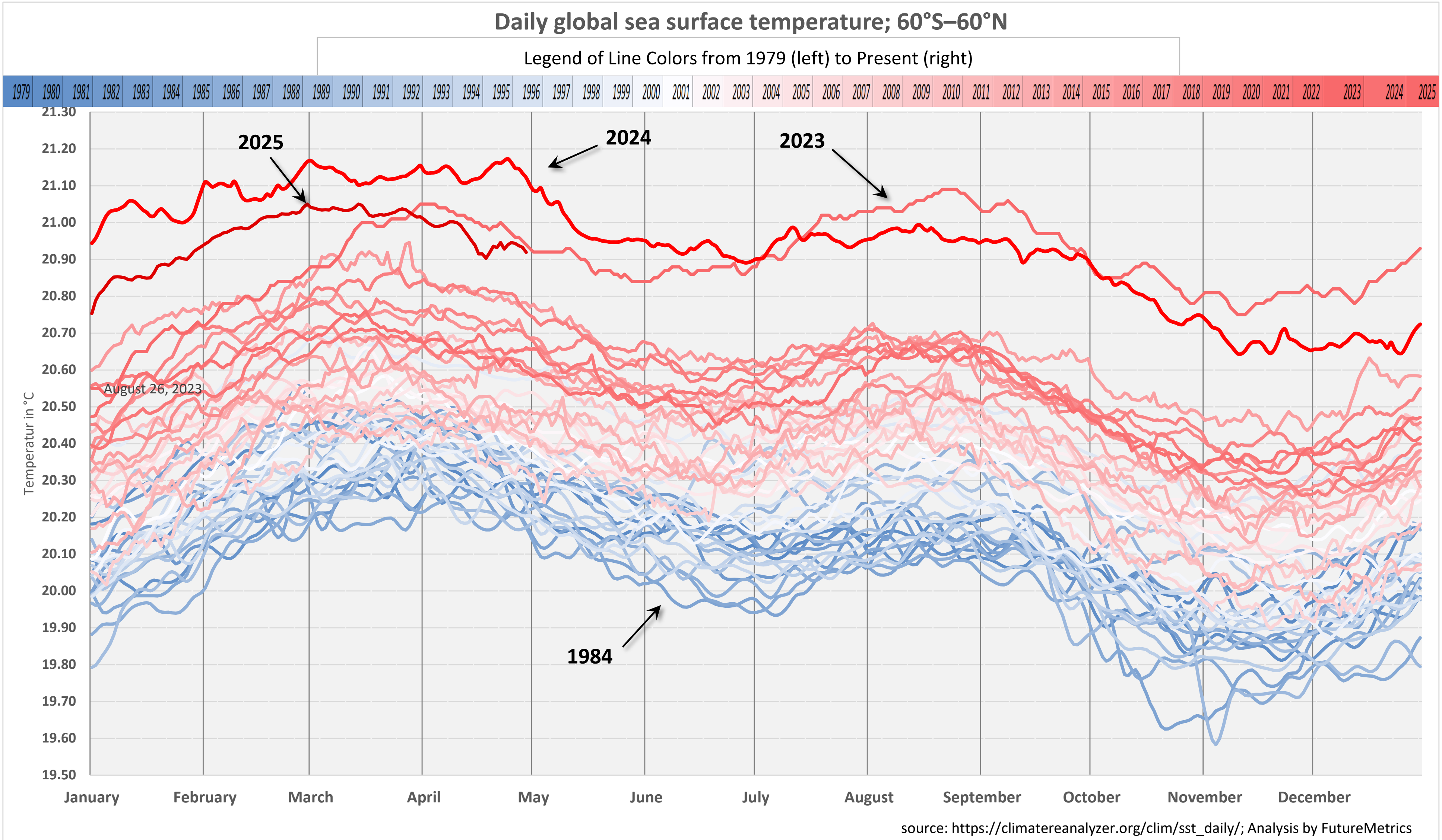

Figure 4 - Sea Surface Temperature 1979 to Present

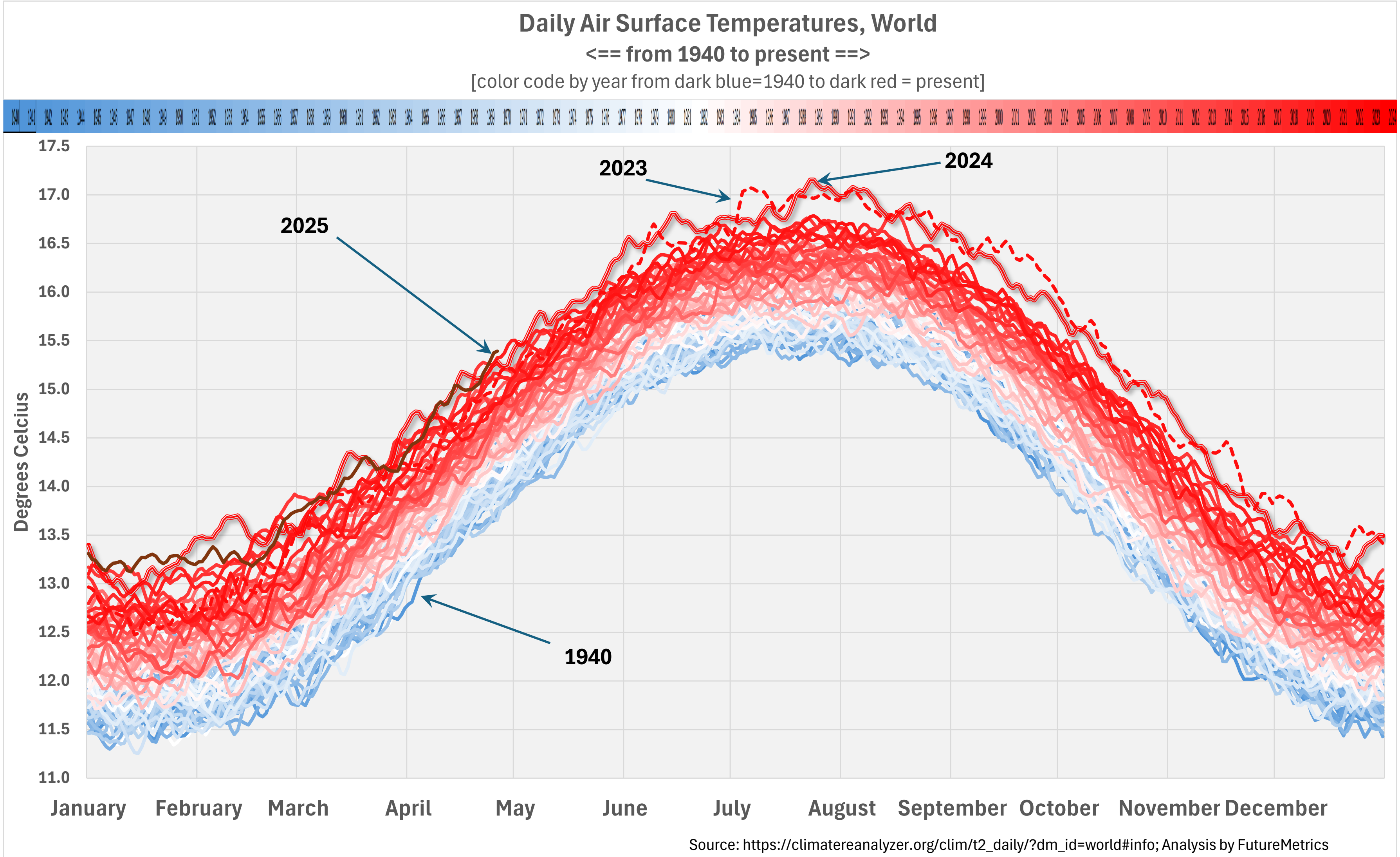

Figure 5 - Air Surface Temperature 1940 to Present

A Pragmatic Strategy that Can Help

An off-ramp to a decarbonized future should include many strategies. Reducing dependence on fossil fuels is foundational. However, the downward slope of the decarbonization off-ramp can be improved with the addition of carbon negative tactics.

FutureMetrics has produced several white papers on bioenergy carbon capture and sequestration (BECCS). The front end of the BECCS supply chain depends on the sustainable sourcing of bioresources. FutureMetrics has discussed the dynamics of forest growth in other white papers[3]. This white paper has nothing new on those topics.

The purpose of this work is to bring the discussion forward and emphasize how forest sustainability coupled with BECCS can support rational climate change mitigation motivated policy. This paper highlights the pathway from the forest to the BECCS station; and ultimately to the permanent removal of CO_2 from the air.

Forest Sustainability is the Essential Starting Point

In every case when forest resources are used as part of a carbon emissions mitigation strategy, sustainability is an absolute necessary condition. That means that the source of the biomass cannot be treated as a depleting resource (which all fossil fuels are). The biomass source must be managed so that, at the very least, what grows every year is always greater than what is removed every year.

With that constraint setting the boundary, the annual quantity of feedstock needed for mills that convert trees grown for the primary forest products industries cannot exceed the annual growth rate of the managed forests surrounding the mills[4].

This white paper is complimented by an updated interactive dashboard that tells the story told below. See Figure 6 on page 7. The dashboard can be opened HERE or from the dashboard page on the FutureMetrics website.

The left third of the dashboard models the start of the supply chain supplying the BECCS project. You, the reader and user of the dashboard, can enter a variety of input assumptions. The default setting has the managed forest size of 200,000 hectares (494,000 acres). To put that into perspective, if the forest was in a perfect circle with no empty spaces, it would have a diameter of 25 kilometers (15.7 miles). The area is 2,000 square kilometers or about 772 square miles[5]. Given the default growth rate of 10 tonnes per hectare per year[6], this forest produces 2,000,000 tonnes every year of new growth[7].

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[3] All past and present white papers are free to download from the FutureMetrics website.
[4] See a FutureMetrics white paper on this topic HERE.
[5] If the forest was a perfect square with no empty space, it would be about 45 km (28 miles) per side.
[6] This is typical for western Canada.
[7] There are many plots of various ages in the aggregated forest landscape. Only a small portion of those plots are mature and harvested in any given year. Those mature plots equal 2 million tonnes. Meanwhile all other growing young and middle-aged plots add 2 million tonnes per year to the forest. See a FutureMetrics dashboard on this topic HERE.

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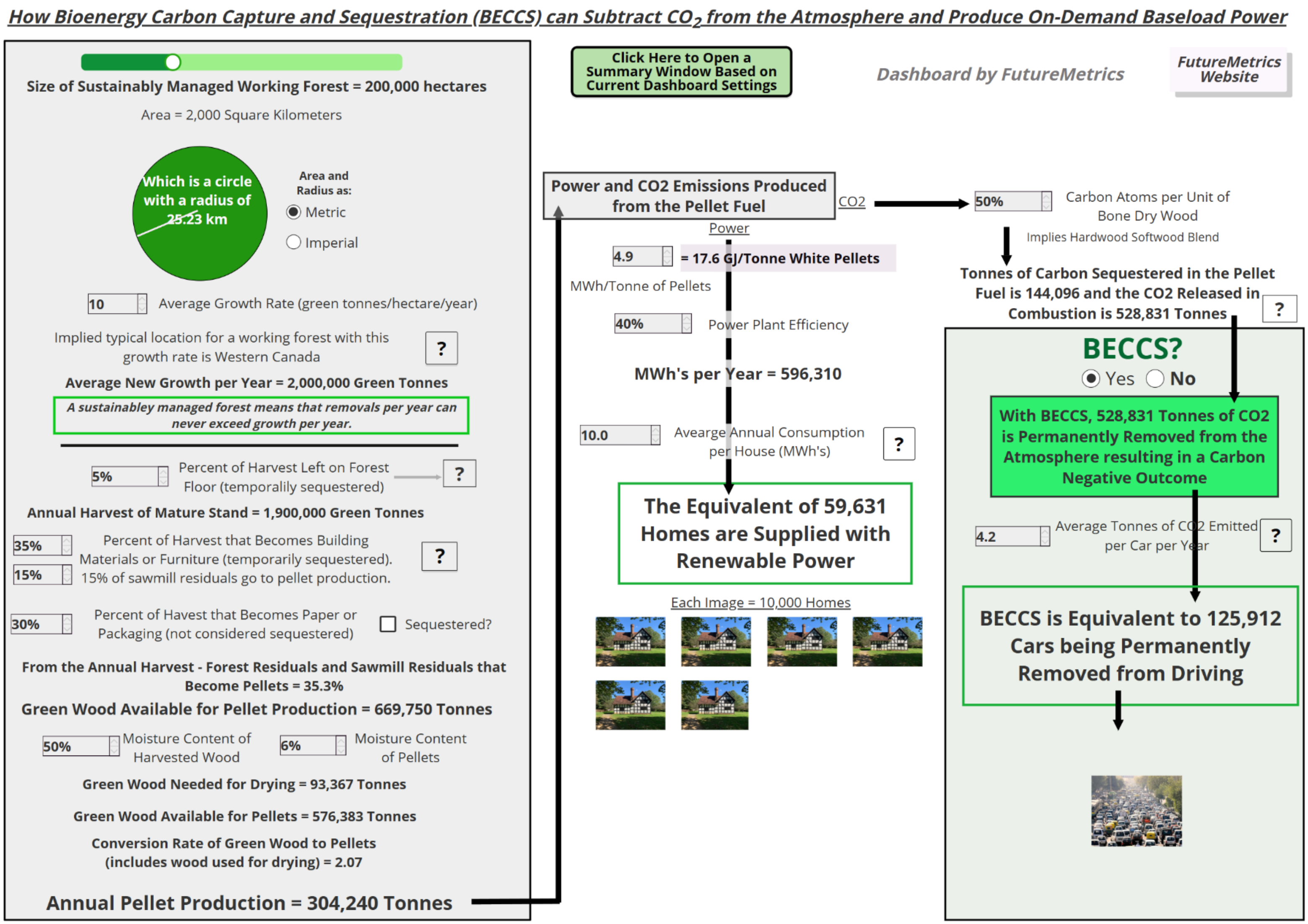

Figure 6 - Dashboard

While 200,000 hectares may sound like a lot, Canada has over 165,000,000 hectares of sustainably managed forests[8]. 200,000 is about 0.12% of the total managed forest land in Canada. The US has 211,000,000 hectares of timberland used for the production of forest projects[9] (200,000 hectares is about 0.09% of the total). There are many other countries with large and well managed forest products industries. And most of the harvests do not convert into pellet fuel. They are being used for products that everyone sees in everyday life.

The default settings for the dashboard have 35% going to building materials, furniture, flooring, etc., and 30% going to paper, tissue, and packaging. 5% of the harvest is left on the forest floor. The default settings have 15% of the sawmilling residues (sawdust, chips, etc.) going to a pellet manufacturing mill and rest of the sawmill by-products going to pulp and paper or engineered wood projects mills[10].

The dashboard under the default settings has about 35.3% of 1.9 million tonnes per year that come out of the dashboard's forest going to the pellet factory (about 670,000 tonnes per year). In many locations the actual percentage is much lower because pulp mills and engineered wood products mills take in much of the same feedstock that a pellet mill would use. So pellet mills are typically not located in regions that already have demand from pulp and paper and other engineered wood products factories.

With moisture content settings using as the default dashboard inputs, that pellet factory can produce about 305,000 tonnes per year of wood pellets.

The production of wood pellets by the dashboard's pellet mill is within the sustainable boundaries of the regional managed forest's ability to have the growth to removal ratio greater than one. In the real world, this same constraint applies, and it is third-party certified by independent audits[11].

The BECCS Project

The BECCS station modeled in this analysis is matched to the output of the dashboard's pellet factory. In the real world, BECCS stations will be supplied by several producers and will therefore likely have significantly larger outputs[12] than what is shown in the dashboard.

The right 2/3 of the dashboard shows how BECCS produces both electricity and permanently removes CO_2 from the atmosphere.

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[8] Citation HERE
[9] Citation HERE
[10] This FutureMetrics dashboard HERE shows the usage of the primary harvest in north America.
[11] See HERE.
[12] For example, the Drax power station in the UK already consumes more than 7 million tonnes per year of pellet fuel to produce, on average, about 8% of the UK's electricity demand. Drax intends to add CCS to the station and sequester CO_2 under the North Sea. See more about the Drax strategy HERE.

The center panel of the dashboard, given the size of the pellet factory in the left panel and the default assumptions, shows that the BECCS project, consuming 310,000 tonnes per year of sustainably produced pellet fuel, will produce enough electricity to supply about 60,000 average sized homes.

But the real value of a BECCS project is the carbon capture and permanent removal of carbon dioxide.

The right-side panel of the dashboard shows that the 305,000 tonnes per year of pellet fuel creates about 530,000 tonnes per year of CO_2 from combustion.

Clicking “No” in the BECCS box on the dashboard highlights the typical carbon neutral benefits of using sustainably sourced pellet fuel for power generation[13]. The CO_2 produced from combustion is cycled back into the growing plots in the forest landscape and the atmosphere sees net zero.

The default setting in the dashboard captures the carbon dioxide and permanently removes nearly 600,000 tonnes per year from the atmosphere.

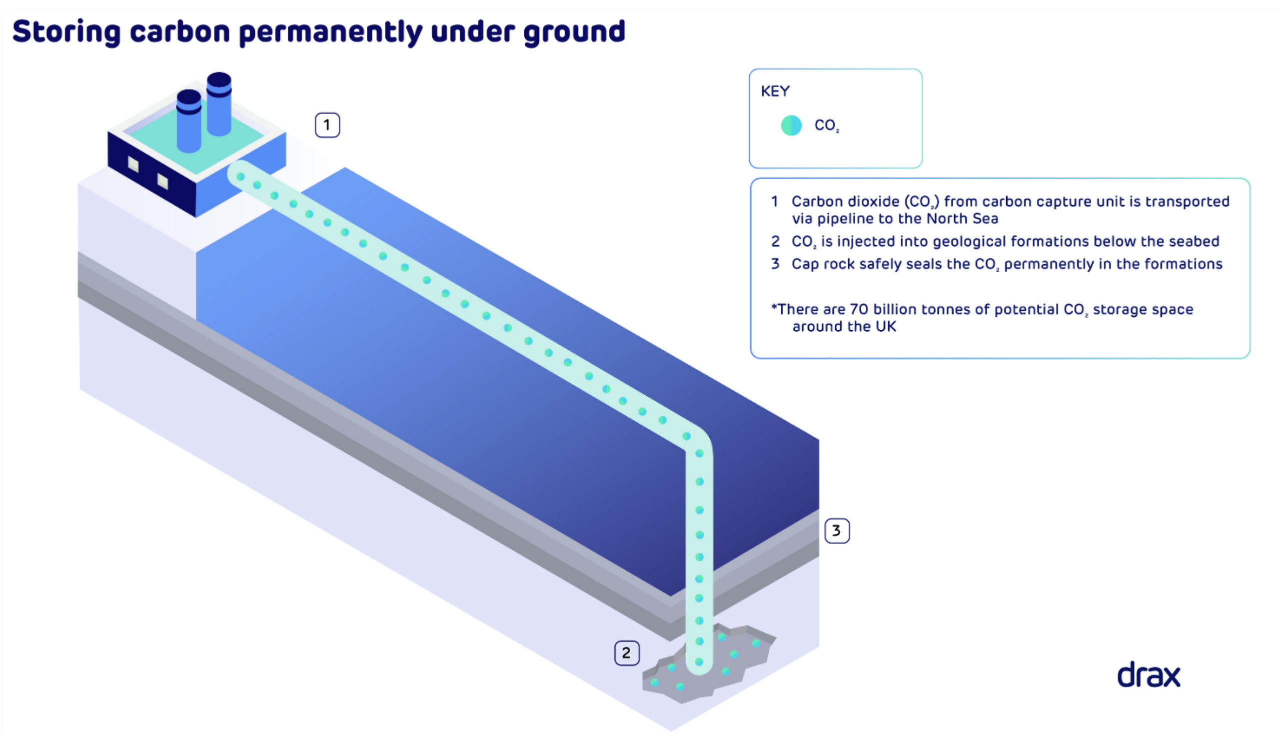

Figure 7 - Permanent CO_2 Underground Storage (courtesy of Drax)

[13] As with all delivered power generation fuels including coal and natural gas, there is a carbon impact from the supply chain’s use of fossil fuels for extraction, refining, and transportation. But for pellet fuel, all of the CO_2 released in combustion is reabsorbed by the new growth. To see the carbon benefit of pellet fuel, including the supply chain carbon footprint, open this dashboard.

Just this one modestly size pellet mill's output supports a BECCS project that results in the equivalent of removing around 125,000 cars from the roads while supplying 60,000 homes with carbon negative power.

Actual BECCS projects will be larger and will be supplied by multiple pellet factories; all of which will be subject to strict oversight to ensure that all sustainability criteria are met.

Final Thoughts

It is a challenging moment in history for many reasons and on many fronts.

With respect to recognizing and acting on the impacts of unabated CO_2 emissions, in some jurisdictions and within certain cohorts, heads are well buried in the sand. But for many, the climate crisis is clear and present. Progress toward decarbonization is still being made in many places.

The transition to renewable low-carbon power and heat generation (wind, solar, sustainably sourced bioresources, energy storage, possibly nuclear), to sustainably produced liquid fuels for long distance transportation, and to sustainable fuels for shipping is underway and will eventually significantly lower CO_2 emissions from combustion.

These are necessary and important. They move us toward net zero in total emissions, but they do not subtract CO_2 from the atmosphere.

Only BECCS from sustainably sourced biomass derived fuel can offer the simultaneous benefits of providing grid-stabilizing baseload generation while also steepening the downward slope on the off-ramp to a future in which atmospheric CO_2 concentrations have returned to levels that give us a chance for the future to be what we would like it to be.